Design

Q: Given a simply supported RC slab 7m × 3m with walls of thickness 30cm all around. Slab carries live load 2 kN/m² & finish load of 1 kN/m². Use M20 concrete & Fe500 steel.

Ans:

1. Determine slab type:

$$\frac{L}{B} = \frac{7}{3} = 2.33 > 2 \Rightarrow \text{One-way slab}$$

2. Determining slab depth:

$$\text{effective span } (l) = \text{shorter clear span} + \text{support width}$$
$$= 3000 + 300 = 3300 \text{ mm}$$

for SSB slabs,

$$\frac{l}{d} \leq 20 \times \text{Modification factor} \quad (\sim 1.25)$$

$$\Rightarrow \frac{3300}{d} \leq 25$$

$$\Rightarrow d \geq \frac{3300}{25} = 132 \text{ mm}$$

Take $d = 175$ mm

Assume effective cover = 25 mm

$\therefore$ Overall depth of slab $D = 175 + 25 = 200$ mm

3. finding effective span:

$$\text{effective span } (l) = \min \text{ of } \begin{cases} \text{c/c dist b/w supports} = 3300 \text{ mm} \\ \text{clear span} + d = 3000 + 175 = 3175 \text{ mm} \end{cases}$$

$$= 3175 \text{ mm} = \underline{3.175 \text{ m}}$$

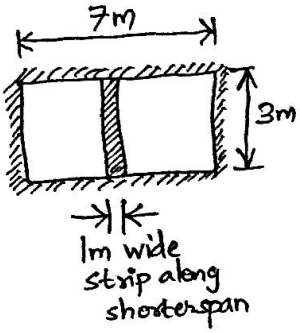
4. Determine moment to be resisted:

$W_{LL} = 2\ kN/m^2 \times 1m = 2\ kN/m$

$W_{FL} = 1\ kN/m^2 \times 1m = 1\ kN/m$

$W_{DL} = 25\ kN/m^3 \times 1m \times 0.20m = 5\ kN/m$

Total load $w = 8\ kN/m$



factored load $w_u = 1.5\,w = 1.5 \times 8 = 12\ kN/m$

factored moment $M_u = \frac{w_u l^2}{8} = \frac{12 \times 3.175^2}{8}$

$= 15.12\ kNm$

5. finding M_{ulim}:

$M_{ulim} = 0.36 f_{ck} b x_{umax} (d - 0.42 x_{umax})$

$= 0.36 \times 20 \times 1000 \times (0.46 \times 175)(175 - 0.42 \times 0.46 \times 175)$

$= 81.83 \times 10^6\ Nmm$

$= 81.83\ kNm$

Since $M_u < M_{ulim} \Rightarrow$ Design is safe & OK

6. finding depth of neutral axis:

$M_u = 0.36 f_{ck} b x_u (d - 0.42 x_u)$

$\Rightarrow 15.12 \times 10^6 = 0.36 \times 20 \times 1000\ x_u (175 - 0.42 x_u)$

$\Rightarrow 15.12 \times 10^6 = 1260000 x_u - 3024 x_u^2$

$\Rightarrow x_u = 12.37\ mm$

$x_{umax} = 0.46d$ (for Fe500)
$= 0.46 \times 175 = 80.50\ mm$

$\therefore x_u < x_{umax} \Rightarrow$ Section is under reinforced

7. Determining tension steel (or Main bars)

Using $x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$

$\Rightarrow 12.37 = \frac{0.87 \times 500 \, A_{st}}{0.36 \times 20 \times 1000}$

$\Rightarrow A_{st} = \underline{205 \text{ mm}^2}$

$A_{st,min} = 0.12\%$ gross area

$= \frac{0.12}{100} \times (1000 \times 200) = 240 \text{ mm}^2$

Since $A_{st} < A_{st,min}$,

provide $A_{st} = A_{st,min} = 240 \text{ mm}^2$

To find spacing b/w bars, assume 12mm ϕ bars,

spacing $s = 1000 \frac{A_b}{A_{st}} = 1000 \times \frac{\pi/4 \times 12^2}{240}$

$= \underline{471 \text{ mm}}$

8. Check for tension steel spacing (or spacing of Main bars)

$s \leq 3d$ or 300mm, whichever is less

$\leq (3 \times 175)$ or 300 mm "

$\leq 525 \text{ mm}$ or 300 mm "

$\leq 300 \text{ mm}$

$\Rightarrow$ Provide 12mm ϕ Main bars @ 300mm c/c

9. Determining Distribution steel

Provide minimum steel area as distribution steel.

$\therefore A_{s(dist)} = A_{st,min}$

$= 240 \text{ mm}^2$

To find spacing b/w bars, assume 12mm ϕ bars.

$\therefore$ spacing $s = \frac{1000 A_b}{A_{st(dist)}}$

$= 1000 \times \frac{\pi/4 \times 12^2}{240} = 471 \text{ mm}$

10. Check for spacing b/w distributors

$s \leq 5d$ or 450 mm, whichever is less

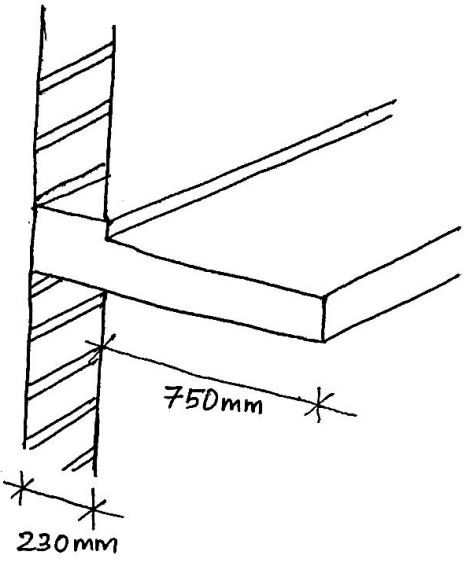
$\leq (5 \times 175)$ or 450mm, "

$\leq 875 \text{ mm}$ or 450 mm, "

$\leq 450 \text{ mm}$

$\Rightarrow$ Provide 12mm ϕ Distribution bars @ 450mm c/c

Q: Design a sunshade slab 3m long with 75cm projection from masonry support of thickness 23cm, is subjected to an imposed load of $5\ kN/m^2$. Use M20 concrete & Fe500 steel.



Ans:

1. Determining slab type:

Since this is a cantilever slab, with bending only along the shorter span, (or projection) this behaves as a <u>one-way slab</u>.

2. Determining slab depth:

$$\text{effective span of cantilevers } (l) = \text{shorter clear span} + d/2$$

$$= 750 + d/2$$

for cantilevers,

$$\frac{l}{d} \leq 7 \times \text{Modification factor } (\sim 1.25)$$

$$\Rightarrow \frac{750 + d/2}{d} \leq 8.75$$

$$\Rightarrow 750 \leq 8.75d - d/2$$

$$\Rightarrow 750 \leq (8.75 - 1/2)\,d$$

$$\Rightarrow 750 \leq 8.25\,d$$

$$\Rightarrow d \geq \frac{750}{8.25} = 90.91\ mm$$

∴ Take $d = 125$ mm

Assume effective cover = 25 mm

∴ Overall depth of slab = 125 + 25
= 150 mm

3. finding effective span:

for cantilevers,

l = clear span + $d/2$

= 750 + (125/2)

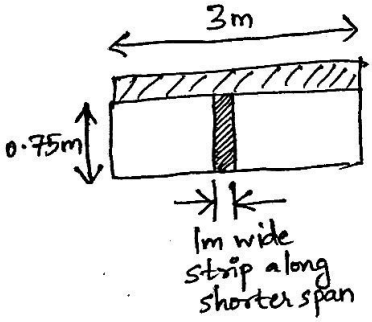
= 812.50 mm = 0.8125 m

4. Determining moment to be resisted:

W_{LL} = 5 kN/m² × 1m = 5 kN/m

W_{DL} = 25 kN/m³ × 1m × 0.15m = 3.75 kN/m

Total load w = 8.75 kN/m



factored load $w_u = 1.5w = 1.5 \times 8.75$
= 13.125 kN/m

factored moment $M_u = \frac{w_u l^2}{2} = \frac{13.125 \times 0.8125^2}{2}$

= 4.33 kNm

5. finding Mulim:

$M_{ulim} = 0.36 f_{ck} b x_{umax} (d - 0.42 x_{umax})$

$= 0.36 \times 20 \times 1000 \times 0.46 \times 125 (125 - 0.42 \times 0.46 \times 125)$

$= 41.75 \times 10^6$ N mm

= 41.75 kNm

Since $M_u < M_{ulim}$ ⇒ Design is safe & OK

6. finding depth of neutral axis:

$$M_u = 0.36 f_{ck} b x_u (d - 0.42 x_u)$$

$$\Rightarrow 4.33 \times 10^6 = 0.36 \times 20 \times 1000 x_u (125 - 0.42 x_u)$$

$$\Rightarrow 4.33 \times 10^6 = 900000 x_u - 3024 x_u^2$$

$$\Rightarrow x_u = 4.90 \text{ mm}$$

$x_{umax} = 0.46d$ (for Fe500)
$= 0.46 \times 125 = 57.50 \text{ mm}$

Since $x_u < x_{umax}$
$\Rightarrow$ Under-reinforced Section

$\therefore$ OK

7. Determining tension steel (Main bars):

Using $x_u = \frac{0.87 f_y A_{st}}{0.36 f_{ck} b}$

$$\Rightarrow 4.90 = \frac{0.87 \times 500 A_{st}}{0.36 \times 20 \times 1000}$$

$$\Rightarrow A_{st} = 81 \text{ mm}^2$$

But $A_{st,min} = 0.12\%$ gross area

$$= \frac{0.12}{100} \times 1000 \times 150 = 180 \text{ mm}^2$$

Since $A_{st} < A_{st,min}$, provide $A_{st} = A_{st,min} = 180 \text{ mm}^2$

To find spacing b/w bars, assume 12mm ϕ bars.

Spacing $s = 1000 A_b / A_{st} = 1000 \times \frac{\pi/4 \times 12^2}{180} = 628 \text{ mm}$

8. Check for spacing of Main bars:

$s \leq 3d$ or 300 mm, whichever is less

$\leq (3 \times 125)$ or 300 mm, "

$\leq 375 \text{ mm}$ or 300 mm, "

$\leq 300 \text{ mm}$

$\Rightarrow$ Provide 12mm ϕ Main bars @ 300mm c/c

9. Determining Distribution steel :

Provide minimum steel area as distribution steel.

$\therefore A_{s(dist)} = A_{st,min} = 180\ mm^2$

To find spacing b/w bars, assume 8 mm ϕ bars

$\therefore$ spacing $s = 1000 \frac{A_b}{A_{st}} = 1000 \times \frac{\pi/4 \times 8^2}{180}$

$= 279\ mm$

10. Check for spacing b/w distributors :

$s \leq$ 5d or 450 mm, whichever is less

$\leq (5 \times 125)$ or 450 mm, "

$\leq$ 625 mm or 450 mm, "

$\leq$ 450 mm

Since $s = 279\ mm \leq 450\ mm$,

provide $s = 279$ mm or any smaller value

$\Rightarrow$ Provide 8mm ϕ Distribution bars @ 250 mm c/c